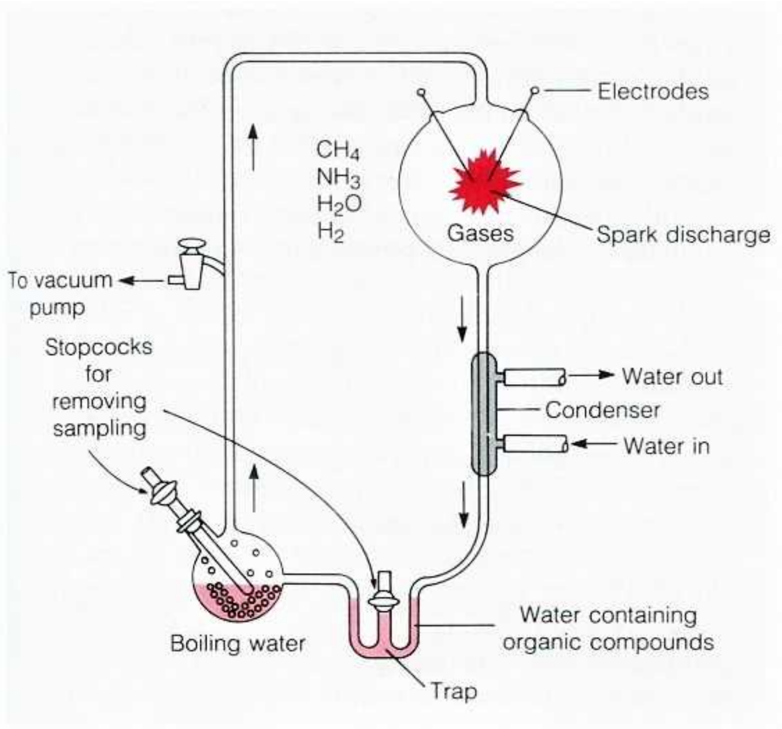
SOLAR FLARES AND THE ORIGIN OF LIFE:

In 1952 the famous **Miller-Urey experiment [below]** proved that lightning in the atmosphere of early Earth could produce the chemical building blocks of life. New research reveals that solar flares might do an even better job.



"The production rate of amino acids by lightning is a million times less than by solar protons," says Vladimir Airapetian of NASA's Goddard Space Flight Center, a coauthor of the paper published April 28, 2023, in the research journal '**Life**'.

Above: An artist's concept of the early Earth

Early research on the origins of life mostly ignored the sun, focusing instead on lightning as an energy source. In the 1950s Stanley Miller of the University of Chicago filled a closed chamber with **methane, ammonia, water, and molecular hydrogen** – gases thought to be prevalent in Earth's early atmosphere – and repeatedly ignited an electrical spark to simulate lightning. A week later, Miller and his graduate advisor Harold Urey analyzed the chamber's contents and found that 20 different amino acids had formed.

"That was a big revelation," says Airapetian. "From the basic components of early Earth's atmosphere, you could synthesize these complex organic molecules."

But then things got complicated, with further research suggesting different ingredients in the young Earth's atmosphere. Scientists now believe ammonia (NH_3) and methane (CH_4) were far less abundant; instead, Earth's air was filled with carbon dioxide (CO_2) and molecular nitrogen (N_2), which require more energy to break down. These gases can still yield amino acids, but in greatly reduced quantities.

Seeking alternative energy sources, some scientists pointed to shockwaves from incoming meteors. Others cited solar ultraviolet radiation. In 2016, Airapetian suggested a different idea: energetic particles from our sun.

Chemistry professor Kensei Kobayashi of the Yokohama National University heard about Airapetian's idea and offered to help test it.

"I was fortunate enough to have access to several [particle accelerators] near our facilities," says Kobayashi. These accelerators could be used to create energetic protons of the type produced by strong solar flares and CMEs.

Next, they set about re-creating the Miller-Urey experiment with a mixture of gases matching early Earth's atmosphere as we understand it today. Kobayashi's team shot the gas-filled chamber with protons (simulating solar particles) or ignited it with spark discharges (simulating lightning), comparing which worked best.

While protons (solar flares) formed amino acids with methane concentrations as low as 0.5%, spark discharges (lightning) required about a 15% methane concentration before any amino acids formed at all. Protons also tended to produce more carboxylic acids (a precursor of amino acids) than spark discharges.

Overall, solar protons outperformed lightning by a factor of a million.

This is significant because the young sun produced a lot of energetic protons. Some 4 billion years ago, the sun shone with only about three-quarters the brightness we see today, but its surface roiled with giant eruptions. "**Superflares**" were common, by some estimates occuring as often as 10 times a day, helping to cook plenty of amino acids.

This doesn't mean solar flares created life, only the building blocks. How non-living chemicals might self-assemble into a living organism remains a mystery.